RDT

Brief

Research Investigation RI 02-016
Research Report RDT 04-017

August, 2004

Design, Fabrication, and Testing of Low-Profile Composite Bypass Road Panel: Phase I

Research Development and Technology

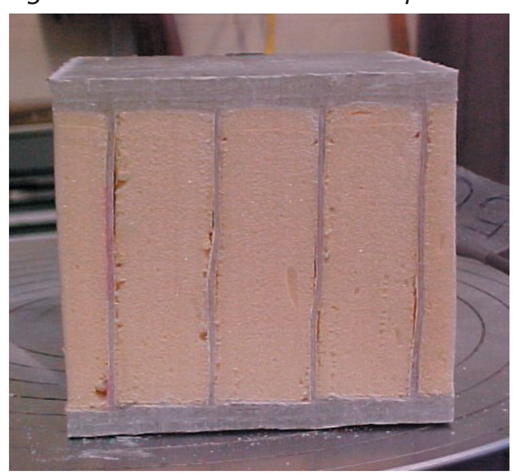
Missouri Department of Transportation

1617 Missouri Blvd.
P.O. Box 270
Jefferson City,
Missouri 65101

Description:

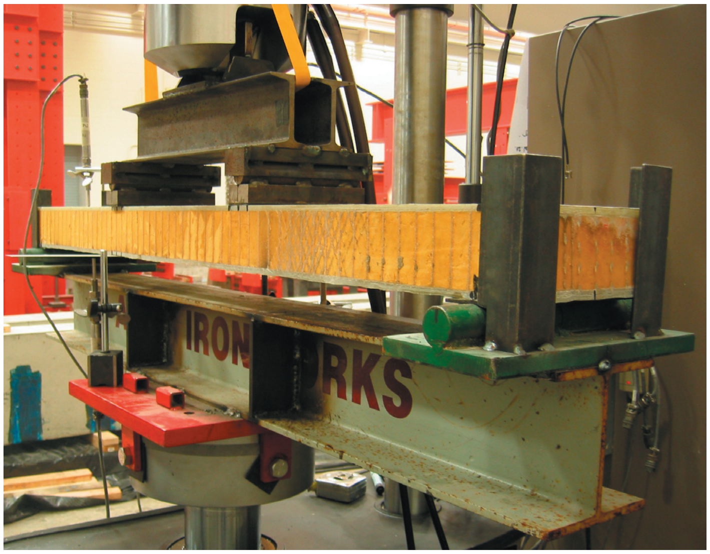
The use of glass fiber reinforced polymer (GFRP) sandwich panels in civil engineering applications, especially for bridge deck rehabilitation and military airfield matting, has become more accepted in recent years as a result of demonstration projects that have shown the concept feasibility in rather demanding transportation infrastructure applications. Typically, these sandwich panels feature a fiber reinforced (bidirectional) high-density foam core and GFRP facings that provide full integrity and strength to the system (Figure 1). The application of GFRP sandwich panels for application in temporary reusable bypass roadways has been identified as a high-interest alternative to traditional construction by the Missouri Department of Transportation (MODOT).

Figure 1: Sandwich Panel Cubic Specimen



In order to investigate the performance of the sandwich construction, an experimental program including static and dynamic fatigue tests was performed, and both tests included two different characterizations: compression and flexure. In both cases, the specimens were conditioned to 500,000; 1,000,000; 1,500,000 and 2,000,000 cycles. The specimens utilized in the experimental program were collected from different sandwich panels with the purpose of verifying homogeneity in the mechanical properties of the material. Cubic specimens of 4 in (102 mm) by 4 in (102 mm) and 3.5 in (89 mm) thick, and two types of beams (longitudinally-cut and transversally-cut) 8 in (203 mm) wide and 58 in (1.47 m) long were utilized in the compressive and flexural tests, respectively. The investigation focused on the ultimate capacity and stiffness (compressive and flexural) of the sandwich structure, as well as its residual strength and rigidity after fatigue conditioning. Figure 2 illustrates the test setup of the Fatigue Flexural Test.

Figure 2: Test Setup – Fatigue Flexural Test



Discussion of Experimental Results:

Regarding the compressive experiments, Figure 3 presents a summary of the data in the form of a S-N diagram, where S is the conditioning load and N is the number of cycles in millions. The letter in the label of each point designates the panel they belong to (A or B), and the number references the conditioning load level (1, 2 and 3). The points with an arrow indicate the set of specimens that did not fail during the conditioning, therefore, for certain number of cycles it was determined their residual strength (hollow points). The colored dots without an arrow represent the series of samples that failed during the fatigue conditioning

Two possible field situations lead to the experimental results obtained in the flexural test: (a) Panel laid over

Figure 3: Conditioning Load S vs. Number of Cycles N

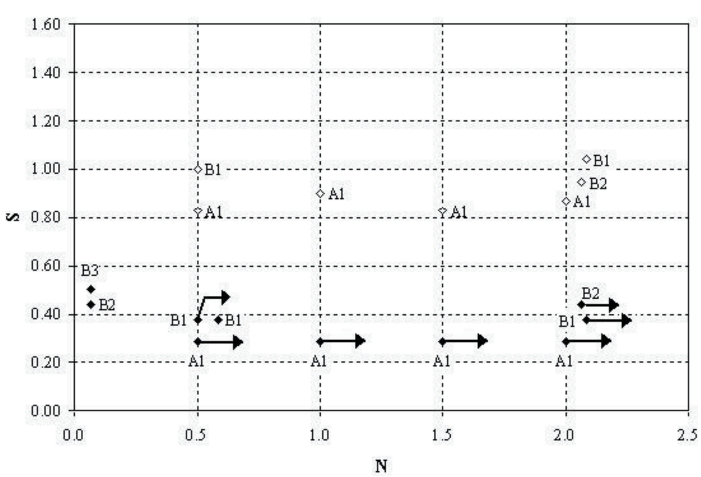
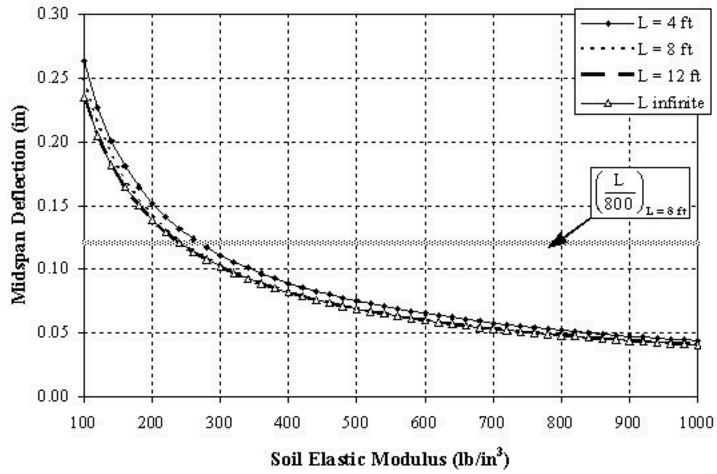


Figure 4: Midspan Deflection vs. Soil Elastic Modulus



an opening; (b) Fully supported panel. For both cases the strength and serviceability criterions were considered. The maximum allowable stress resulting from the tests was 9.5 ksi (82.3 MPa), and the deflection limit recommended by AASHTO (1996) for concrete slabs of the ratio of the span length over 800 (L/800), was considered suitable for this application. The design load corresponded to an HS25-44 truck.

Case (a) was analyzed as of a panel placed over a culvert and fixed at both ends (connection system), with the peak tire load applied at midspan. For case (b) the analysis was carried out as of a panel supported by an elastic foundation or a spring bed. In addition to the aforementioned criterions, the bearing capacity of the substrate on which the panel is laid was another factor to be taken into consideration. Figure 4 shows a family of curves, representing the midspan deflection of different length sandwich beams as a function of the soil modulus K, was constructed. The beams show significant similarity among the plots corresponding to the 8 ft (2.44 m), 12 ft (3.66 m) and an infinite length beam. A 4 ft (1.22 m) long beam or shorter does not meet the design requirements established for this application.

Conclusions:

The residual compressive strength after two million cycles is 869 psi (6 MPa), which is considerably higher than the peak surface pressure resulting from an HS25-44 truck wheel of 100 psi (6.9 kPa) over a 200 in^2 (1290 cm^2) area. From the difference of the experimental strength with respect to the demand truckload, a factor of safety equal to 8 is attained.

The span length of 2.8 ft (58.34 cm) was found as the maximum opening dimension the sandwich panel could be placed over and safely withstand a design load corresponding to HS25-44 loading truck.

For the case of a not connected panel fully supported by a substrate with certain bearing capacity, 4 ft (1.22 m) and shorter lengths are not recommended since the midspan deflection is a critical issue, not to mention the implicit demand for a stronger substrate (higher soil elastic modulus). The length of 8 ft (2.44 m) for this situation is considered appropriate, not only for inferring permissible deflections for reasonable soil modulus but also for satisfying bending strength requirement.

For more information contact:

Antonio Nanni
Jones Professor of Civil Engineering
224 Engineering Research Lab
1870 Miner Circle
University of Missouri - Rolla
Rolla, MO 65409-0710
Tel: (573) 341-4497
Fax: (573) 341-6215
nanni@umr.edu

Daniel J. Smith
Research and Development Engineer
Missouri Department of Transportation
1617 Missouri Blvd.
P.O. Box 270
Jefferson City, MO 65109
Tel: (573) 526-4329
Fax: (573) 526-4337
Daniel.Smith@modot.mo.gov